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**JOINT FORCES STAFF COLLEGE**  
**JOINT ADVANCE WARFIGHTING SCHOOL**

**Joint Sustainment of Weapon Systems**

**Would We Be Better Off?**

**By**

**MAJ HALL, RICHARD A.**

**A paper submitted to the Faculty of the Joint Advanced Warfighter School in partial satisfaction of the requirements of a Masters of Science Degree in Joint Campaign Planning and Strategy.**

**The contents of this paper reflect our personal views and are not necessarily endorsed by the Joint Forces Staff College or the Department of Defense.**

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14 April 2006

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## **ABSTRACT**

The US military is faced with some significant challenges in the coming years. While transforming its organizational structure it must simultaneously reset its equipment and the force all the while maintaining its operational tempo with the war on terror. As resources become more constrained, the military must find a way to execute its mission in a more efficient and effective way. This paper looks at the requirements for implementing these changes, the current competing economic and military forces in play and possible solutions for an improved depot level system.

As depots within the military begin to implement new procedures based on the Lean Six Sigma model, a proposed consolidation of efforts based on major weapon systems could lead to improved cost benefits and decreased maintenance time. Tied with the current Joint Depot Maintenance Program, Lean Six Sigma can continue to improve the Service's depot performance.

## **INTRODUCTION**

Current plans for the U.S. military have it doing something that has never been done in the history of these forces. The military is simultaneously conducting a complete refurbishment of its equipment called reset, transforming its organizational structure and conducting the War on Terrorism. The Global War on Terrorism alone has placed a significant strain on Soldiers and their equipment. The addition of reset and transformation to this operation tempo (OPTEMPO) has undoubtedly added additional stress and will require the military establishment to rethink its way of doing business.

The military leadership is aware of these pressures and has made it clear that a change is imperative. In a statement before the Subcommittee on Military Readiness House Armed Services Committee, then Army Deputy Chief of Staff, G-3, who later became the Vice Chief of Staff of the Army, General Richard A. Cody remarked, “We have designed a process of reconstituting our current equipment by undertaking a rigorous long-range plan known as Reset for short. This plan requires intensive resourcing, repair and overhaul of our ground equipment and aircraft, and prioritizing and streamlining of our facilities and personnel to support these efforts.”<sup>1</sup> General Cody’s statement lays out a critical and difficult task for our military to undertake but obviously one that is necessary. After looking at what reset entails, decisions to recapitalize equipment, the defense industrial base strategy, and current Joint Doctrine on depot level repairs, this paper will address the challenges and possible solutions given specific examples of multi-service pieces of equipment.

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<sup>1</sup> General Richard A. Cody, Deputy Chief of Staff, G-3, United States Army, Opening Statements and Press Releases, 108<sup>th</sup> Congress, October 21, 2003.

Reset and recapitalization being essential actions necessary to refurbish and improve our current weapon systems, efficiency and effectiveness must remain foremost in the execution of these actions. Time, money and quality are the bottom line in this process. The measure of effectiveness is when the weapon system makes it back to the Soldier when he needs it, in a high quality of performance state, and with little disruption to the unit's training and equipping timelines as possible. To achieve this, it is important to look at is the efficiency and effectiveness of the depot repair systems. All of these, though seemingly obvious, are areas that need to be considered and improved where feasible.

When discussing money and the cost of reset/recapitalization, looking at governmental influences upon the process and the effectiveness of its control in addition to the service specific ways of doing business is critical. Is this Nation, and the services specifically, spending the taxpayer's dollars wisely, getting the best product for the dollar? Additionally, is the performance from the depots and industry being maximized to successfully meet the demand of the combatant commanders? Are the depots that are utilized to perform the reset and recapitalization services working to become more efficient through the use of new technologies and methods of operations?

The final question, and possibly most important, should ask if the product is a quality product and whether it is making it back to the unit in time for training and deployment. Before a unit returns from rotation, it preps and loads its equipment to be transported back to its home station. Upon the equipment's return, the unit will conduct an inspection of its equipment. After inspection, a decision is made as to what level of work the equipment will undergo.



The desert is a harsh environment and all the equipment down to the smallest pieces, night vision goggles and individual weapons, will undergo some form of maintenance. Due to the increased OPTEMPO of the equipment, most of the main weapon systems, vehicles and aircraft will undergo reset if returning from either OEF or OIF. A commander understands that all of his aircraft will undergo reset but cannot afford to induct all of his aircraft into the process at once because he has training and certification of pilots to conduct. In a perfect world, this would not be an issue but most likely his unit is scheduled for a rotation to one of the training centers and then back on a deployment. Time is a factor and is the most constrained resource in a commander's planning for the induction of his aircraft into the reset or recapitalization process.

Reset and recapitalization are not options as they are measures that provide Soldiers with the best possible equipment to train and fight with and serve as risk mitigation factors for the continued safety of the Soldiers as they conduct operations. This time constraint is a challenge for the combatant commanders that must be met with a resolution to improve the efficiency and effectiveness of current depot level operations.

The military needs to look for a new way of doing business as its budget for acquisition of new military equipment decreases and the OPTEMPO remains the same or increases. The military is forced to extend the life of its legacy systems. These current weapon systems are faced with escalating operations and maintenance costs. These costs are due to:

- Increased OPTEMPO
- Increased mean time between maintenance cycles due to increased OPTEMPO.

- Increased life extension of existing weapon systems due to delays in new system acquisition.
- Unforeseen support problems associated with aging weapon systems.
- Material shortages because of diminishing manufacturing resources and technological obsolescence.<sup>2</sup>

Understanding the issues and challenges ahead will help better answer the question of whether joint sustainment of weapon systems would enhance the ability of the Combatant Commanders and Joint Task Force Commanders to accomplish their missions.

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<sup>2</sup> Agripino, M., Cathcart, T., & Mathaisel, D., Ph.D., *A Lean Sustainment Enterprise Model for Military Systems*, Acquisition Review Quarterly, Fall 2002.

## **RESET DEFINED**

The first step to the solution is to understand the need to reset equipment and what reset specifically means to a weapon system. As outlined by Dr. David Chu, Under Secretary of Defense (Personnel and Readiness) in testimony before the Senate Armed Services Committee, “reset comprises a series of actions to restore units to a desired level of combat capability commensurate with mission requirements and availability of resources:

- replacing battle losses and washed out equipment (damaged to the degree that repair is not economical);
- recapitalizing equipment that needs extensive refurbishment, implementing lessons learned where sensible/affordable; and
- repairing existing equipment in accordance with applicable Army maintenance standards.”<sup>3</sup>

Mentioned within the reset definition above, the recapitalization effort seeks to “modernize onboard electronics, restore airframe integrity and improve flight performance for the existing fleet.”<sup>4</sup> Recapitalization focuses primarily on the Reserve and National Guard components, which fly older model aircraft. This is an effort to synchronize compatibility with the active force in maintenance and capability of the aircraft. Maintenance depots for each service provide these services, with separate contracts between each depot and industry partners.

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<sup>3</sup> Dr. David Chu, Under Secretary of Defense (Personnel and Readiness) in testimony before the Senate Armed Services Committee, 30 June 2005, AUSA Torchbearer Issue, October 2005, page 3.

<sup>4</sup> *Aviation Recapitalization: An Imperative for Today and Tomorrow's Army*, Association of the United States Army, January 2003, Issue 10: Aviation Recapitalization, page 1.

The War on Terrorism has required the deployment and redeployment of many units, not just to Iraq or Afghanistan but sometimes to both in subsequent years, tiring both the personnel and the equipment of these units. This holds true not just for the active force but for the reserve components as well. This constant rotation of units into the theaters of operation provide little time for the units to repair, retrain and refit themselves. It has been estimated that equipment has exceeded its normal peacetime usage by 6-10 times. Figure one depicts an analysis of equipment deployed for a one year period. It shows that deployment in the GWOT ages the vehicles up to eight times as fast as under peacetime conditions. The predicted and predictable miles usage of peacetime operations due to limitations placed on units during peacetime is exponentially increased by current operations. This directly translates to a premature solution for the resolution of repairing the legacy force or replacing it.

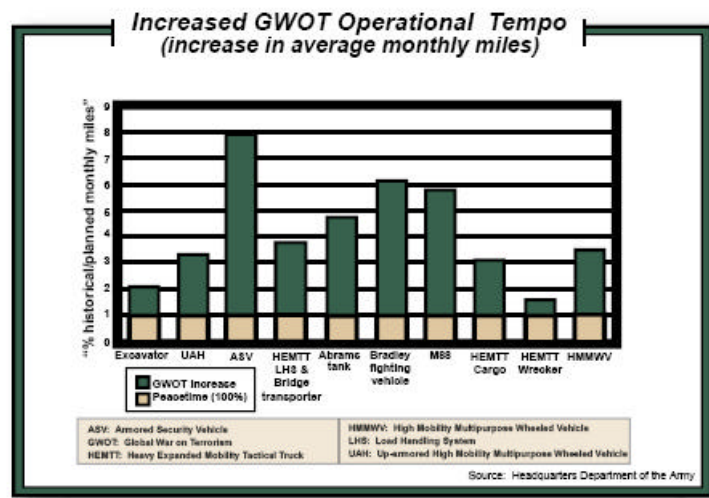


Figure1 Increased GWOT OPTEMPO

General Cody commented on the number of Soldiers just from the U.S. Army, National Guard and Reserve deployed in our on-going efforts. His statement demonstrates the extent of activity that US forces are faced with almost 275,000 Soldiers deployed in more than 120 countries today.<sup>5</sup> The need for unit readiness is at a constant rate of increase and the ability to deploy with serviceable equipment is paramount.

Why this is important is evident in the readiness rates as depicted in figure 2 on ten of the Army's critical weapon platforms. Reset and recapitalization become a necessary alternative as the cost of replacing equipment both in time and in dollars will never meet the desired numbers of systems needed to continue to prosecute our military obligations throughout the world. The graph clearly indicates that the Army will continue to assume risk until about 2 years after the end of current hostilities.

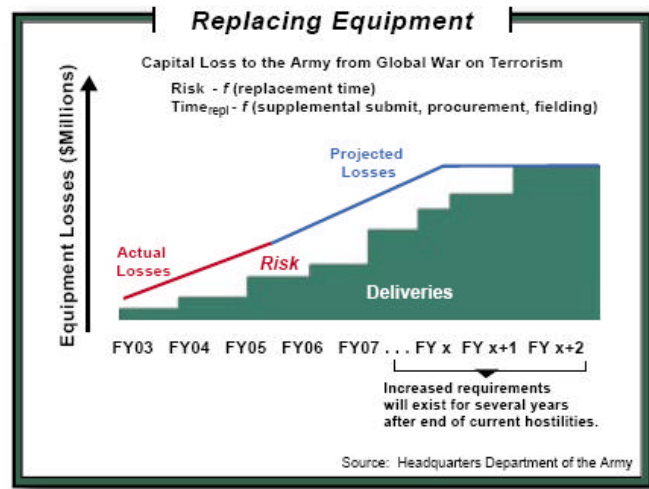
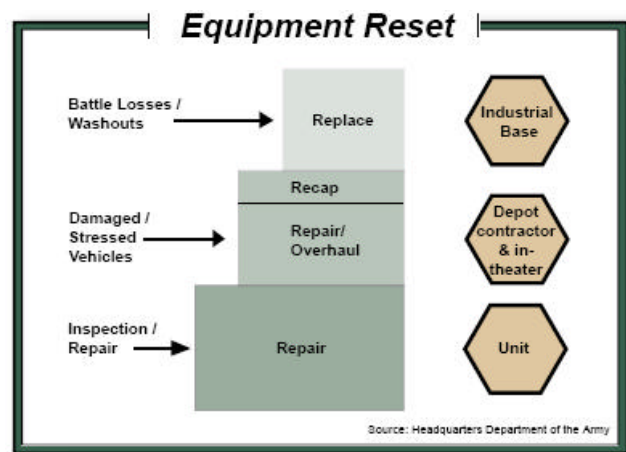


Figure 2 Losses vs. Deliveries

<sup>5</sup> Sergeant Rebecca Crister, *Vice Chief reports Army status at Defense Forum*, Army News Service, 21 September 2004.

Increased usage and a slow repair cycle pose some critical questions. The end or desired result of the refit, reset process is to essentially return the equipment back to the Soldier and or unit in original equipment manufacturer (OEM) condition and if required, upgraded to current standards. The organization must first determine the cost of resetting the equipment vice the cost of replacing it and then this will determine which process the equipment will go through. Figure 3 gives a simple representation of the different levels and who is responsible for each. If the equipment is a total loss through battle damage and the cost of repair would exceed the cost to replace, then the decision would be to replace it and the military must rely on current contracts with industry and the current production schedule established in these contracts.

Since the goal of industry is to make money, one of two things need to happen in the case for replacement: 1) The military will have to spend more to amend any contracts so that industry will increase production to meet military demands or 2) The military will have to come up with alternatives to replacement. Later this paper will address the challenges the Department of Defense faces with its current procedures and interactions with industry. The ultimate solution will be the one that addresses all the issues above, but most notably which gets the equipment back to the Soldiers in the best condition possible.



**Figure 3 Equipment Repair/Replace Decision**

For the sake of understanding the military's position on defense industrial base and current strategy regarding replacement of equipment, this paper will now examine the current defense industrial base strategy.

## **DEFENSE INDUSTRIAL BASE STRATEGY**

What is the defense industrial base? Hartley and Sandler's *Handbook of Defense Economics*, defines it as, "...those companies which provide defense and defense related equipment to the defense ministry."<sup>6</sup> J.P. Dunne, the author of this chapter in Hartley and Sandler's book, warns that a superficial view of the defense industrial base (DIB) can be detrimental to the assessment and analysis of the controls and proposed solutions to improving the DIB. The components of the DIB range from high technological and high cost weapon systems down to inexpensive small arms and components. Dunne breaks the DIB into these three categories:

- (i) Lethal Large or small weapons systems
- (ii) Non-lethal but strategic products (e.g. vehicles and fuel)
- (iii) Other products consumed by the military (e.g. food and clothing)<sup>7</sup>

For the purpose of narrowing the focus this paper will look specifically at categories (i) and (ii) although all three categories prove to be essential in the final product.

Given this definition of the DIB, what controls does the US Government have on its defense industrial base? Currently the United States works within a free market society that allows or requires industry to bid for contracts with the government. Is this enough control? Is more needed to ensure timeliness of parts, mechanical support, end-items? Should the government control more of what happens in the industrial sector to protect our national interests? Specifically, should the government be able to override

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<sup>6</sup> J. Paul Dunne, *The Defense Industrial Base*, Handbook of Defense Economics, vol.1, Keith Hartley and Todd Sandler, 1995.

<sup>7</sup> Ibid.



current contracts to allow for the quick replacement of parts and major weapon systems back to the military?

There are several thoughts and many papers on the defense industrial base strategy and the amount of control that the US government should take. Concepts vary for how the government should manage the DIB in order to achieve the desired outcomes.

The effects of the DIB on the economy, the society and national security are not new factors to be considered by a nation. As America emerged from the Second World War and a boom in the technological and industrial sectors, it was faced with a dilemma. Dwight D. Eisenhower brought to light this tough question in his farewell address on 17 January 1961 when he said, “This conjunction of an immense military establishment and a large arms industry is new in the American experience....In the councils of government, we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for a disastrous rise in misplaced power exists and will persist. We must never let the weight of this combination endanger our liberties or democratic process.”<sup>8</sup>

Theodore H. Moran holds the Marcus Wallenberg Chair at the School of Foreign Service in Georgetown University and serves as the director and founder of the Landegger Program in International Business Diplomacy at the university<sup>9</sup> and published a paper on defense economics and security. In it, he looked at some of the proposed strategies and their effects if implemented in today’s acquisition and sustainment process.

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<sup>8</sup> Dwight D. Eisenhower, *Farewell Address 17 January 1961* (<http://www.eisenhower.archives.gov/farewell.htm>).

<sup>9</sup> Institute for International Economics, Visiting Fellows and Other Authors, [http://www.iie.com/publications/author\\_bio.cfm?author\\_id=56](http://www.iie.com/publications/author_bio.cfm?author_id=56).

A process that historically Adam Smith and other philosophers of the Scottish Enlightenment believe provided a social and moral justification for commerce. The American Founders were deeply influenced by these Scottish thinkers. The mixture of free markets with the civic vibrancy of early America created a new form of social life. The Founders wanted to promote the general welfare and secure the blessings of liberty through civic activity, religious life, and commerce. Commerce is the element that is the focus for the discussion here.

Mr. Moran outlines the two main schools of thought, between which debates about government policy towards civilian industries that are vital to national defense have swung ...<sup>10</sup> He explained the two extremes with regards to influence on the defense industrial base and then provided three strategies by which the government can try to influence the industrial base. The two contending schools of thought that are mentioned are National Self-sufficiency and Market Forces.

#### Schools of Thought

National self-sufficiency upholds that there are defense industry sectors that are too important to be at the mercy of the free market forces. More specifically, it contends that the defense-industrial base, especially when critical to the national defense, needs to be under the control of the government to ensure the nation's safety. The nation should get all of its product and resources from within, relying on no other external country for any part of production. This obviously reduces the risk incurred by the purchaser of having to rely on another nation for a product. Should the U.S. require assistance from other nations, the amount of control by the government to influence any changes in

production rate or efficiency is reduced as the supplier is not subject to our rules or laws. Additionally, the supplying nation could refuse production or supply of product thus putting a stop to production or an increase in price as alternative solutions are sought out. Regarding situations that involve critical weapon systems, it would seem to make sense that the government provide some sort of protection and rely on the national self-sufficiency concept.

Another key characteristic of national self-sufficiency is that the government would be responsible for the selection of which sectors it will protect and support and which it will not. Through selection as a government protected industry, that industry would be protected from competitors and other influences of a free market society. Others along with Theodore Moran contend that by doing this, the U.S. would be subjecting itself to a limited selection of quality. Some term it the “Infant Industry Argument.”<sup>11</sup>

Selection to protect certain industries will cause two things. The protected industry could slide into a secure and less productive state in which their protected status would not breed efficiency but would do the counter and cause the industry to grow stagnant and the government to continue to bear the cost for protection. Competition through the free market approach causes industries to continue their research for the better product and most efficient methods in order to gain the contract. Additionally, by picking one industry over others that may be within the same market for that product, resentment is created and the country faces potential retaliation, not just from the non-selected industries but also from the host nations of those industries, thus creating a

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<sup>10</sup> Theodore H. Moran, *Grave New World, Security Challenges in the 21<sup>st</sup> Century* ( Michael E. Brown, Editor, Georgetown University Press, 2003).

hedge amongst the economic and diplomatic societies. Arguments have been made that despite differences between nations, free trade will stem the thought of going to war as an open trade agreement will build a mutual dependence upon each other...one for the product and the other for the economic benefit of providing that product. Those who support national self sufficiency assume that those designating a particular industry for selection will do so unfailingly and without coercion, which may not be the case. Proponents of free trade will argue that, “Government agents cannot make the calculations necessary to judge which industries to protect, when to protect them, and how much protection to provide. Government officials will tend to provide this protection based on political judgments. Private industry can undertake the monetary calculation needed to make investment decisions and will do a better job of allocating resources to a war effort.”<sup>12</sup> Even within the current free market society, the power of the dollar and lobbyists can secure large contracts not because of a company’s unique product or capability but because it is tied to the selector in some way.

As opposed to those who support self-sufficiency, others promote reliance on the free market to select the best candidate for the project. Advocates of market forces contend “...that governments should rely solely on international market forces to determine the composition of activities within national markets.”<sup>13</sup> By allowing the market to decide the best candidate, it will result in the choosing of the most efficient and maximized output. The contention is that private industry can recognize any shifts in market and will shift its efforts to meet the demand. An industry’s desire for profit and

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<sup>11</sup> Mark Brandly, *A Primer on Trade*, Mises Institute, November 04, 2002.

<sup>12</sup> Ibid.

<sup>13</sup> Theodore H. Moran, *Grave New World, Security Challenges in the 21<sup>st</sup> Century* ( Michael E. Brown, Editor, Georgetown University Press, 2003).

its fiscal responsibility to investors is better suited to meet the nation's needs than the decision of the government which may be more politically swayed than focused on efficiency and well spent funds.

A major concern with the free market model is that the US is continuing to be outpaced by other nations. Thomas L. Friedman discusses this concern in his book, *The World is Flat*. He commented as he was walking through a major technological corporation in India how the hustle and bustle of the “zippies,” software and technical engineers, was causing him to believe the David Ricardo was correct. David Ricardo was an English economist who developed the free-trade theory of comparative advantage. This theory states that nations will specialize on a particular product which it has a comparative cost advantage and trade with other nations for the products that they have a comparative cost advantage. Trade between the US and India is an indicator that this process is happening and correct. What caught Friedman's eye, though, was the fact that there were so many of the Indian techies and they looked eager and willing to work and to do the same work as Americans for much less money.<sup>14</sup> This might then create a concern that critical jobs could possibly fall to other nations as corporations look to increase their profit margin all the while providing the same if not improved product to the American consumer. This possibility is what the proponents of the national self-sufficiency concept use to influence and strengthen its position.

Given these two divergent methods, common sense and history show us that balance somewhere in between must be found. The national self-sufficiency model brings with it the idea of control and guidance where the free market model brings with it the challenge of competition to be more efficient, effective and innovative. America, as

mentioned earlier, being based on its founding fathers desire to “promote the general welfare and secure the Blessings of Liberty” through civic activity, religious life, and commerce, is generally considered a free market based economy.

Despite this fact, Theodore Moran lays out three arguments for governmental influence within the free market world that can help bring a balance and set some sort of “controls” to protect the nation’s defense industrial base: public support for research and development, strategic trade theory and avoiding dependence on concentrated suppliers. The first two require an offensive move by the government to step out and assist industry. The government could fund programs for specific R&D or give a R&D tax credit to industries that would not normally pursue a program because the cost of R&D would be far greater than the profit from the product. By creating these incentives, the government is getting highly competitive and technical industries involved in the production of specific military capabilities that otherwise they would not engage. Likewise, the strategic trade theory, “... suggests that individual states may have an interest in intervening in the marketplace to create, support, and preserve national companies in industries where there are market imperfections, dynamic learning, and first-mover advantages that generate economic or political-military externalities from the operation of those firms.”<sup>14</sup> Theodore Moran goes on to explain that strategic does not imply military tactics but the tactics of “gaming” within the market society to ensure that the backed industry succeeds within the trading game over those not located within the nation state. Of course, this form of government intervention or protection of home nation based

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<sup>14</sup> Friedman, Thomas L., *The World is Flat*, Farrar, Straus, and Giroux, New York, 2005.

<sup>15</sup> Paul R. Krugman, *Strategic Trade Policy and the New International Economics* (Cambridge: MIT Press, 1986.).

industries places the onus of selecting the “winning” industry on individuals rather than the free market, quite possibly hampering the outcomes as earlier discussed.

The third control, avoiding dependence on concentrated suppliers, is indirectly an offensive strategy as well. It is “...aimed at avoiding dependence on external suppliers who may be able to deny, delay, or place conditions on the provision of products and inputs.”<sup>16</sup> The idea is not to let any one firm control more than 50 percent of the supply. The more firms that are added to the mix, the less control any one firm has on delaying or denying any product. Theodore Moran demonstrates that reliance upon one supplier or a number from a small number of countries can provide significant risk to the dependant nation. The only possible solutions for the government’s involvement would be to require that foreign firm to establish plants in the home country or to build a similar capability within the home country.

Why is this backdrop for discussion of government involvement in the defense based industry important? Because as the military continues to fight the Global War On Terror, transform into a lighter more flexible and deployable force, and reset its equipment, the need for products has increased and therefore so has the demand from industry. Most industries outsource parts of an end-item out to other specialized firms. The tools discussed above on how the government can get involved and massage the system to assist industry with meeting its required demand from the military are important to understand but what cannot be forgotten is that the bottom line for industry is to make money and be fiscally responsible to its investors. What this most likely means for the government is an increase in spending to ensure that industries make

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<sup>16</sup> Laura D’Andrea Tyson, *Who’s Basing Whom? Trade Conflict in High-Technology Industries* (Washington D.C.: Institute for International Economics, 1992).

enough profit to support their continued production of needed materiel. As discussed earlier, this would be one course of action for the military, to spend more money to amend current contracts with industry and modify current production schedules. Industry builds its production schedules based on contracts it has signed and any amendments to increase production could result in additional costs from starting up new production lines to increasing jobs or extending overtime. All of these cost money and ultimately cost the consumer, the US military, should it desire or demand that its needs be met and that production lines be added to meet them.

In the balance lie national security and the freedom of a capitalistic society that values the opportunity to make more and be better than anyone else. Should more power or control other than that discussed be given to the government or should the American public understand the ebbs and flows of economic progress and live with the imperfections of governmental, industrial and economic procedures?

The imperfections with these procedures are the very things that protect the process and all that Americans hold true. Should the U.S. diverge from the minimal abilities of the government's influence on industry, it will slowly slip from the democratic republic that it is and towards a socialist society that has proven ineffective through failed nation's examples. President Eisenhower voiced his concern of too much governmental control or power in conjunction with the defense industry during his farewell speech in 1961, which he said,

Although, most arguably, the defense industrial base is neither the most efficient or effective process; the balance created between the free market forces and the selective governmental interventions, keeping watch over possible infringement on our basic rights and societal



constructs, provides us with a solution that over years has progressed into the interconnected entity that doesn't disrupt our republic sensibilities and still provides us the capability to maintain our defense superiority and bolster our economic superiority at the same time.<sup>17</sup>

So, does this mean that the U.S. should continue along the path that it is on, one where each service is left to its own paradigm and stove-piped procedures of operation? No, partnerships with leading industries and the wider implementation of the Joint Depot Maintenance Program (JDM) are the ways ahead. This may seem a little optimistic in concept but in reality such efforts are currently being instituted and are proving effective.

It is all a matter of cross-talk and mutual respect. Where the CEOs of industry are looking at the profit margin and fulfilling their fiscal responsibilities to their employees and investors, the military leaders are looking at the sustainment of their capabilities and materiel and safety responsibilities to the Soldiers in the field. Although divergent at first glance, the two work hand-in-hand and mutually support each other. By meeting the requirements of the government, industry provides for itself a safe and secure environment and a growing economy with which to work.

When considering the idea of partnership, it is important to understand the functional workings of the Joint Depot Maintenance Program in order to provide a solid basis for recommendations towards improvement.

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<sup>17</sup> Dwight D. Eisenhower, *Farewell Address 17 January 1961* (<http://www.eisenhower.archives.gov/farewell.htm>).

## **JOINT DEPOT MAINTENANCE PROGRAM**

The Joint Depot Maintenance (JDM) Program is a collaboration of Logistics representatives from the Army, Navy, Air Force, Marine Corps and the Defense Logistics Agency. The scope of the JDM is to, “address the full range of support elements, including hardware, software and facilities, which may be applied in providing depot maintenance support for weapon systems, end items, and their components.”<sup>18</sup> Managing the JDM through a charter from the logistics representatives of the JDM is a body of individuals known as the Joint Group on Depot Maintenance (JG-DM). The JG-DM is charged with the direction and control of the activities within the JDM. The concept of a JDM has been around for quite a long time and has gone through some changes since its inception in 1974. Below is the brief timeline of the JDM program and significant changes that have occurred over the last 31 years.

**1974:** Joint Logistics Commanders (JLC) established the Joint Technical Coordinating Group for Depot Maintenance Interservicing (JTCDG-DMI) to develop specific interservice policy and a continuing definitive action program to implement this policy., now the Joint Group on Depot Maintenance (JG-DM), and maintenance interservice support management offices for each branch of the military to improve interservice cooperation.

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<sup>18</sup> OPNAVINST 4790.14A/AMC-R 750-10, AFI21-133(I)/ MCO P4790.10B/DLAD 4151.16, Joint Depot Maintenance, 31 March 1999

**1974 - 1977:** Services reassigned postured equipment and saved millions of dollars primarily by eliminating duplication.

**1977:** JLC formed the Maintenance Interservice Support Group-Central (MISG-C) at Tinker AFB OK to review new acquisitions and identify costs DOD would avoid by interservicing depot workload.

**1980:** JLC formed the Joint Aeronautical Depot Maintenance Action Group (JADMAG) to develop a master plan for the Defense Department to size the aeronautical maintenance depots.

**1982:** MISG-C and JADMAG merged to become the Joint Depot Maintenance Analysis Group (JDMAG). JDMAG's responsibilities included assigning depot sources of repair, integrating the Services' depot maintenance plans, and reviewing military construction proposals.

**1984:** JDMAG moved from the Washington Navy Yard, Washington, D.C., to Gentile Air Force Station, Dayton, Ohio, where its mission expanded to include technology exchange.

**1996:** JDMAG moved to Wright-Patterson AFB, Ohio due to the imminent closure of Gentile Air Force Station.

**1998:** JDMAG's name changed to Joint Depot Maintenance *Activities* Group following an internal review by the JG-DM and redirection by the JLC.<sup>19</sup>

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<sup>19</sup> <http://www.jdmag.wpafb.af.mil/history.htm>.

Through the establishment and growth into the JDMAG, the JDM established these primary objectives:

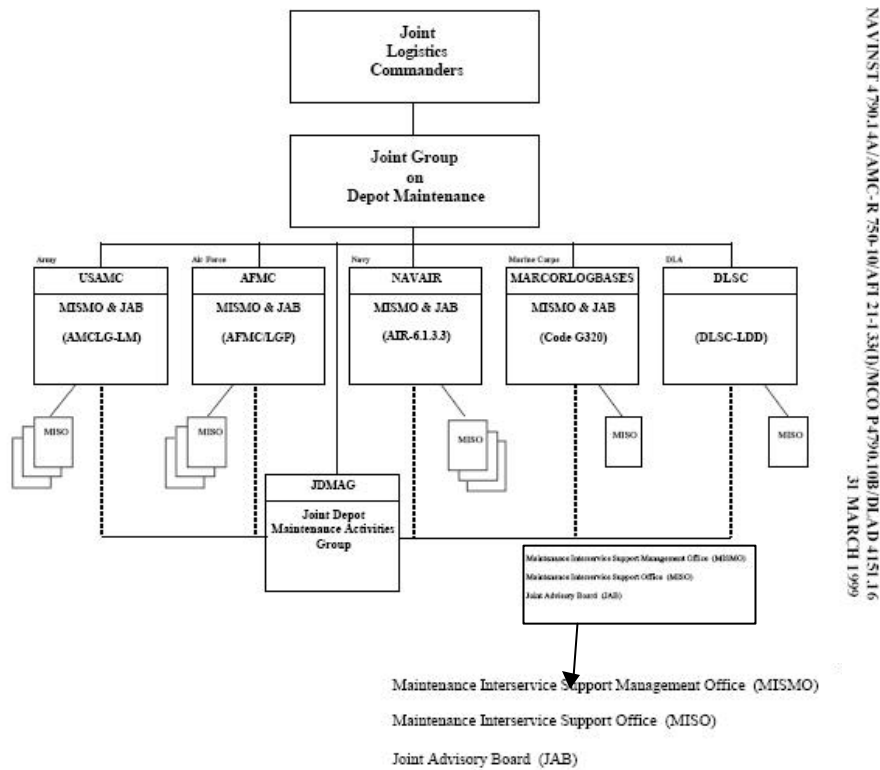
- a. Implement DoDD 4151.18, Maintenance of Military Materiel, and DoD 5000.2-R, Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information (MAIS) Acquisition Programs, as they apply to depot maintenance.
- b. Provide the process and procedure for assigning depot sources of repair (DSOR).
- c. Provide the process and procedures for reviewing depot maintenance military construction (MILCON) proposals to consider interservice alternatives.
- d. Provide guidance for conducting competitions between public depot maintenance activities, and guidance for public depot maintenance activities involved in competition between public activities and private entities.
- e. Facilitate interservice organic and joint contract depot maintenance support to achieve the most cost effective support possible, consistent with the readiness requirements of the Services.
- f. Facilitate the exchange of technology information as a means to improve productivity and achieve more cost effective operations in the Services' depot maintenance activities.

- g. Facilitate joint Service business planning for depot maintenance support and management.<sup>20</sup>

Given these objectives and procedures, once a weapon platform is determined to need depot level repair, the JDMAG, in accordance with the OPNAVINST 4790.14A/AMC-R 750-10, AFI21-133(I)/ MCO P4790.10B/DLAD 4151.16, Joint Depot Maintenance, 31 March 1999, is responsible for providing technical support to the JDM Program in functional areas including joint business planning, policy assessment, technology information exchange, Depot Source of Repair (DSOR) assignment studies, DSOR implementation tracking, and other depot maintenance related initiatives. Assisting in the JDM Program are the Joint Advisory Board (JAB) and Maintenance Interservice management Offices (MISMO). Figure 4 depicts the organizational structure of the JDM Program.

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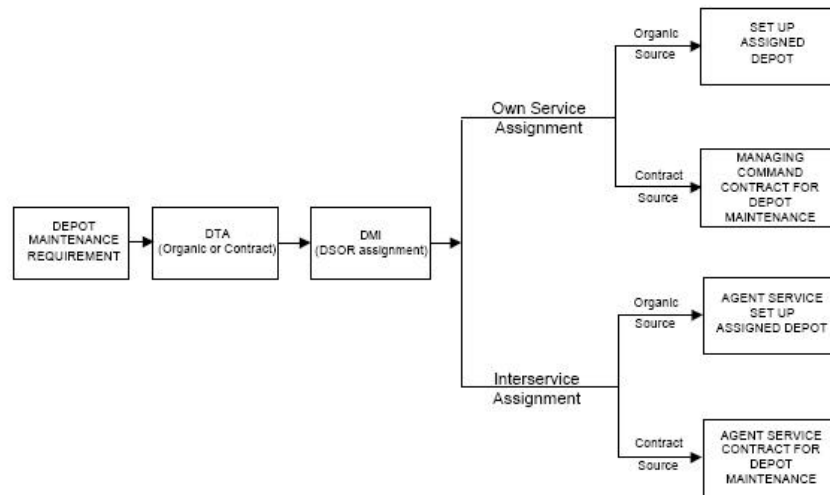
<sup>20</sup> Ibid.



**Figure 4 JDMP Organizational Structure**

The Joint Advisory Board serves as the secretariat to the Director of the JDMAG and provides recommendations on current missions also serving as a liaison between the Service MISMOs and the JDMAG. The MISMOs serve a similar purpose but instead of coordination up to the JDMAG, their focus is to provide liaison back to their respective services and ensure synchronization with any DSORs. Personnel to fill positions in both the JAB and MISMOs are provided by the Services.

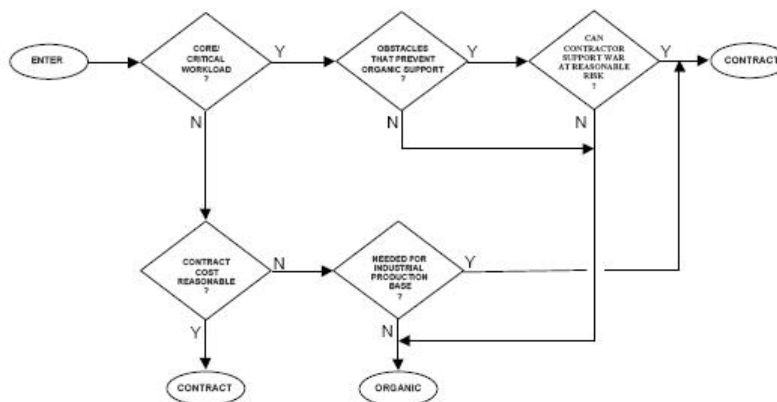
With this supporting cast and representation from all services to include the Defense Logistics Agency, the recommendation for depot repair enters the DSOR decision process shown in figure 5.



OPNAVINST 4790.14/AMC-R 750.10/AFI 21-133/D/MCO P4790.10B/DLAD 4151.16  
31 MARCH 1999

**Figure 5 DSOR Decision Process**

During the Decision Tree Analysis phase (DTA) (Figure 6) the service requiring depot level services will determine whether the project is best suited for organic or contract service. After using the decision tree and deciding to go with organic depot support, that is, maintenance services that are resident within the Service, then the Depot Maintenance Interservice (DMI) Review will determine, based on factors ranging from cost to capabilities of the different depots, which Service is best suited to conduct the depot maintenance. A Depot Source of Repair will then be prepared and presented to the JDMAG. There are several layers of concurrence between services and their MISMOs in the preparation of the DSOR. Once the DSOR is decided and concurred upon by all, it will be presented to the JDMAG for recording and announcement.



OPNAVINST 4790.14A/AMCR 750.10/AFI 21-1330/MCO P4790.10B/DLAD 4151.16  
31 MARCH 1999

**Figure 6 Decision Tree Analysis**

Several very successful examples of the inter-service maintenance effort are ongoing and will be highlighted in following sections.



### **MILITARY DEPOTS**

Depots have been an integral part of the defense industrial base for a long time but they came into prominence during the Second World War. As far back as the beginnings of this great country, individuals have provided services in the depots that support the troops in the field. After General George Washington assumed command of the Army, Congress appointed the first Quartermaster General, Major General Thomas Mifflin. Major General Mifflin was responsible for working with the separate states to provide for the Army but with little success. Not until Major General Nathanael Greene, the third Quartermaster General took over after Valley Forge was there an attempt to reorganize the supply system. Major General Greene established the first depot system to support the Army. The depot system was responsible for everything from transportation,

clothing, laundry services, ammunition and rations to burial duties to name just a few areas.

The depot system continued to grow and refine its processes but really did not see a big change until the Second World War. From the war of 1812 through the Second World War, with the exception of weaponry and transportation, there was not a large change in technology that required any significant changes in our depot system. As the United States began to crawl out of the depression and enter into WWII, the War Department realized a need to generate products quickly to support the war effort. Somewhat hampering the demand for products was the reduction in available workforce as the majority of capable male employees were being drafted. The workforce then came from the available American citizens, women and the few men that did not meet the physical requirements for service in the military.

The civilian nature of these depots has not changed much from the WWII era. In fact, many of the people who work at the depots are one in a long line of family members that lived near the depots and have continued the heroic tradition of providing goods for the military. Currently, the only military personnel on Army depots for the most part are the Commander and the Command Sergeant Major with a few other administrative personnel. The depots are essentially a civilian run entity with military supervision.

Since the conclusion of WWII and the Korean Wars, depot capabilities surged in the anticipated necessity for them to surge to meet the Soviet threat during the Cold War. The threat of the Cold War pushed many depots to maintain the capability to surge to

three 24-hour shifts if needed. This retained capability cost the taxpayers but provided a state of preparedness that many people desperately wanted.<sup>21</sup>

When the Cold War ended, the US Defense Industry found itself with excess capacity and a reduction in the number of new weapon system orders. This caused an understandable downsizing of the depots and consonantly raised the concerns of the members of Congress that had these depots in their districts. Base Realignment and Closure lists already placed considerable concern on the communities and “as a result of the last three Base Realignment and Closure actions, the Defense Department has closed 97 major military facilities and over 200 smaller installations. Included in these closings (2003) were aviation depots, two shipyards and several combat vehicle maintenance facilities.”<sup>22</sup> The number of employees within the depot workforce dropped from 163,000 in 1987 to about 77,000 in 2003. Despite the dramatic decrease in employment, the depots maintained an excess capacity.

Congress continues to protect the depots and “has legislatively declared its position on the need to retain an ‘organic’ source of maintenance and repair nearly every year for the past 15 years.”<sup>23</sup> The Department of Defense agrees with Congress on this fact but disagrees on how the depots should be managed. Congress has passed a few laws that limit the depot’s discretionary action.

The first is a law that referred to as the 50-50 rule. This law requires the services to spend no more than 50 percent of their depot maintenance funds on private sector work. Many in the Pentagon feel that the Congressmen passed this law to protect their

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<sup>21</sup> Peter M. Steffes, *Military Depots: Politics Undermines Cooperation*, National Defense Magazine, July 2003.

<sup>22</sup> Ibid.

<sup>23</sup> Ibid.

interest within their districts, specifically the depots. As suggested early in this paper, this action by the government reduces the advantage of the services benefiting from the new technologies and upgrades that private sector can provide.

A similar “protectionist” rule is the one that requires the Defense Department to have the capability to maintain a weapon system within four years of its initial operational capability. This does not require all maintenance capability be housed within the depots but merely requires the capability for the depots to do the service. Without this provision, the depots would quickly fall from the necessity category to the outdated, as the evolution in technology grows more and more rapid each day. By requiring the capability, the work force and depot facility are keeping up to speed with current technologies and procedures.

Two things that are working against the depots are the fact that many of the items on the weapon systems are commercial derivatives and the way contracts are written. Many of the gears, engines, diagnostic equipment and instrumentation in weapon systems today are direct spin-offs of a commercially used product. Given this fact, there is, for a free market proponent, no need for the depots to spend money or effort to try to duplicate an already existent maintenance capability in the civilian sector. This assumes the civilian industry is doing the maintenance here and not, for example in China. Tied to that, contracts are now being written so the manufacturer becomes the maintenance provider. This saves the services the dollars that would be required to pay for the technical data packages and the time, effort and money required for the depots to re-tool and re-train their workforce.

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Given these challenges, Peter Steffes, vice president of government policy at the National Defense Industrial Association, proposes that the only viable solution to the struggle between government depots and private contractors is partnering.

### **CHANGE...DO WE NEED TO**

The challenges are not just about the physical structures and entities as outlined above but are also and most certainly the mere premise of change itself. Change, regardless of how beneficial the outcome may be or how much it may improve the current methods of operation, is never easy to accomplish. Dr. Spencer Johnson speaks on this point in his book, *Who Moved My Cheese*. The US military and the depot managers have all grown to love the way things are done. It has made them happy, met their requirements and they are comfortable with the way things are. As an example of the level of contentment, one of the little people in Dr. Johnson's book wrote on the wall,

“The more important the Cheese is to you, the more you want to hold onto it.”<sup>24</sup> The cheese in Dr. Johnson’s example represents the depots and the current method of operations. The depots have played a major role and continue to do so in the organizational structure of the military. In order to change such a historic and long standing organization it will take some serious effort from all who are involved. At the risk of becoming extinct and depot operations being removed from the military, the US military must make an effort to change.

As Dr. Johnson’s characters understood that they may become extinct if they didn’t move in search of more cheese, they made their way through the maze again. So must the military’s way of depot operations change in an effort to avoid becoming extinct. But the characters continued to doubt and miss the comfort of the way things used to be in their safe and cheese full past. Beginning their journey into the maze, one of the people, Hem, wrote on the wall to try and encourage his partner Haw. This is what he wrote, “If you do not change, you can become extinct.”<sup>25</sup> This is true for American depots as well as services are beginning to be provided by other organizations at an improved rate and quality to that of the military. The services have some very real fears though, as do the Congressmen who have these depots in their districts. There are fears of job loss, major contract changes and mergers of businesses. Those fears are not fully justified as is illustrated through the military’s move toward a better way of doing business.

So, what is this new way ahead? Lean. Lean is a concept that has its definable beginnings in the early 1990s. It was first defined in a book by Womack, Jones, & Roos,

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<sup>24</sup> Johnson, Spencer Dr., *Who Moved My Cheese*, G.P. Putnam’s Sons, New York, 2002 p. 36.

<sup>25</sup> Ibid.

titled *The Machine That Changed the World*. The book documents how Toyota automobile production underwent a series of systematic reviews and then after making some changes, increased efficiencies in the manufacturing process.<sup>26</sup> Other industries have taken notice and so too has the military. Lean has several key characteristics that will assist in understanding how this change can improve the current practices within DoD:

- Lean is a dynamic process of change driven by a systematic set of principles and best practices aimed at continuously improving the enterprise.
- Lean refers to the total enterprise: from the shop floor to the executive suite, and from the supplier to the customer value chain.
- Lean requires rooting out everything that is non-value added.
- Becoming Lean is a complex business. There is no single thing that will make and organization Lean.<sup>27</sup>

Here is where Lean can mean less. For example, Lean creates less waste, less design time, less cost, fewer organizational layers and fewer suppliers. Lean can also mean more in terms of employee empowerment, more flexibility and capability, and more productivity, more quality, more customer satisfaction, and more long term competitive success.<sup>28</sup> This sounds like common sense and something that all involved would like to move towards but as stated earlier, change is scary and Lean, as mentioned, is not a sole task change but a systems change throughout.

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<sup>26</sup> Womack, J., Jones, D., & Roos, D., 1990, *The Machine That Changed the World*. New York: Rawson/MacMillan.

<sup>27</sup> Agripino, M., Cathcart, T., & Mathaisel, D., Ph.D., *A Lean Sustainment Enterprise Model for Military Systems*, Acquisition Review Quarterly, Fall 2002.

So where is the start point? How do we know if an entity is Lean or not? What metrics are used to allow the analysis and determines the path toward becoming Lean? Ways to determine the level of Lean include using other industries, direct competitors, external function best operators, or generic functions regardless of industry along with basic standards of performance are. Some of these may include reduction of cycle time, lowering costs, minimizing waste and improving quality.<sup>29</sup> An example of comparison between a mass production facility and a Lean production facility is highlighted in figure 7.

So, can Lean benefit the military? A review of the current system and possible solutions that can be realized through the implementation of Lean will be discussed next.

	GM Framingham	Toyota Takaoka
Assembly hours per car	31	16
Assembly defects per 100 cars	130	45
Assembly space per car	8.1	4.8
Ave. inventory of parts	2 weeks	2 hours

**Figure 7. Example of Mass Production vs. Lean Production**

### The Current Military Sustainment System

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<sup>28</sup> Nightingale, D., *Integrating the Lean Enterprise*. MIT Presentation, <http://Lean.mit.edu> 2000.



The current military sustainment system is comprised of four major elements: (1) Supply Support, (2) Intermediate/Depot Maintenance and Operational Support, (3) Integrated Logistical Support (ILS), and (4) the In-Service Engineering process. Although mainly comprised of four major elements, figure 8 demonstrates that it is a complex myriad of crossed lines and multi-level coordination.<sup>30</sup>

Figure 8 shows the Supply Support Function made up of the supply system, the Government Industry Data Exchange Program (GIDEP) and the supply chain. The supply chain is comprised of the vendors (v) and the suppliers (s) who provide the materials and refurbishment services to the supply system and the depots. These in turn are managed by the item manager at the Inventory Control Points (ICP) and the supply inventory is maintained at the Designated Stock Points (DSPs).

The Intermediate and Depot Maintenance portion is the maintenance portion that is responsible for keeping weapon systems in a serviceable condition. The depots are the location within the military that is responsible for this function. This is where the reset and recapitalization process happens. Additional to the reset and recapitalization functions, the Designated Overhaul Points (DOP) or depots, are responsible for the following which can be, but is not always a portion of the reset or recapitalization process: servicing, inspection, test, adjustment, removal, replacement, reinstallation, troubleshooting, calibration, repair, and modification of weapon systems.<sup>31</sup>

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<sup>29</sup> Agripino, M., Cathcart, T., & Mathaisel, D., Ph.D., *A Lean Sustainment Enterprise Model for Military Systems*, Acquisition Review Quarterly, Fall 2002.

<sup>30</sup> Ibid.

<sup>31</sup> Jones, 1995; Blanchard, Vernma, & Peterson, 1995.

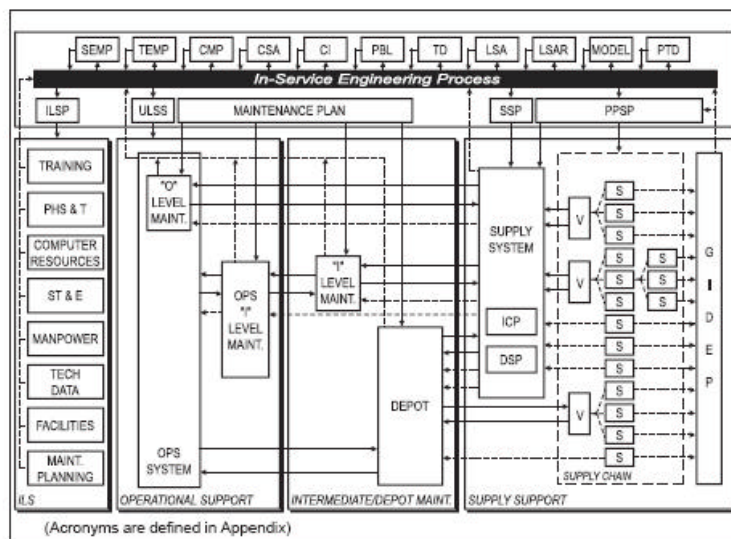


Figure 8. Current Military Sustainment Model<sup>32</sup>

At the depot, maintenance data and failure analysis is provided up to the In-Service Engineering Process. The depot can procure consumable materials from the supply system and/or commercial sources as depicted in the figure 8. Operational support is provided directly to the customer and works in support of the depot system.

The Integrated Logistics Support System function is a culmination of logistics infrastructure that ensures that the weapon system continues to be maintainable and at an efficient and economical rate. The primary objective is to maintain system readiness. All of the elements necessary to sustain the weapon system are included in the ILS to include training and support, packaging, handling, storage, transportation, and computer resources/support.<sup>33</sup> The final block at the top of the diagram is the In-Service

<sup>32</sup> Ibid.

<sup>33</sup> Agripino, M., Cathcart, T., & Mathaisel, D., Ph.D., *A Lean Sustainment Enterprise Model for Military Systems*, Acquisition Review Quarterly, Fall 2002.

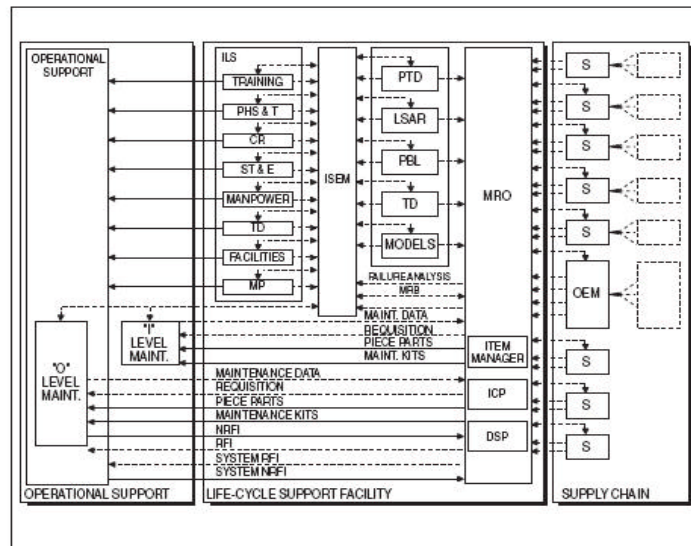
Engineering Process. The In-Service Engineering Process is where post production support plans and product improvements occur with regard to the operation, maintenance, and integrated logistic support of all weapon system support elements.

#### Proposed Model

Having looked at the current model for sustainment and maintenance of a weapon system, Drs. Agripino, Cathcart and Mathaisel provide the following proposed model for Lean sustainment. Dr. Agripino was a researcher for the Massachusetts Institute of Technology's Lean Sustainment Initiative and is currently employed at the Naval Undersea Warfare Center in Newport, Rhode Islands. Dr. Cathcart is also employed at the Naval Warfare Center and served as the Director of the Lean Sustainment Initiative. Dr. Mathaisal's focus is on the sustainment of complex and aging systems and new techniques for the optimization of air transportation systems and he currently serves as an associate professor of Management Science at Babson College as well as a Research Scientist at the Massachusetts Institute of Technology. As discussed, the current model for sustainment is complex, multi-lined and multi-layered. The Doctors propose that in order to move toward a more Lean model of sustainment, there must be a consolidation and integration of many of the existing functions, particularly, In-Service Engineering, Integrated Logistics Support, Intermediate/Depot Maintenance, Operational Support, and Supply Support. The proposed model can be seen illustrated in figure 9.

The proposed model is noticeably cleaner in the number of lines and transactions required between the key sustainment functions. In fact, the developers of this model have consolidated and integrated the sustainment functions into three sustainment

functions: Operational Sustainment, Sustainment Engineering, and Maintenance Repair and Overhaul operations. All three operations are consolidated under one Life Cycle Support Facility.



**Figure 9 The Lean Sustainment Enterprise Model**

With the consolidation into the Operational Sustainment process, all the traditional Integrated Logistics Sustainment functions of training, packaging, handling, shipping, and transportation (PHS&T) and the computer resources can be synchronized. With the arrival of new information technologies and collaborative work environments, the time wasted “sending” necessary requests, making changes in maintenance procedures, issuing guidance on technical improvements and tracking of repair parts will be significantly decreased and conflicts in guidance can be resolved more expeditiously.

The intent is to “eliminate many traditional logistic infrastructure bureaucracies that were established during the Cold War.”<sup>34</sup>

The Integrated Systems Engineering Management (ISEM) within the life cycle facility will tie together the provisioning technical documentation (PTD), product baseline (PBL) maintenance, technical data (TD) packages, and engineering models. System engineers will have the capability through the use of engineering analysis software to monitor and correct operational sustainment problems including, technology obsolescence, aging systems, reliability performance degradation, and maintenance engineering management. All of this will allow for quicker problem identification and resolution to minimize cost and mission readiness impacts.

The last key component in the Life Cycle Facility is the Maintenance Repair and Overhaul structure. Inside the MRO, the ICP and the DSPs reduce the number of levels that the supply chain has to go through. Currently there are seven levels to the supply chain; with this proposed model it will be reduced to three. This change will result in greater asset visibility which in turn will mean the right part available at the right place at the right time.

### **BENEFITS OF LEAN**

Streamlining the current process into the proposed process can provide many benefits such as increased efficiencies in lead times and turn around times to obtain low cost, high quality, and materiel availability.<sup>35</sup> The Lean approach will allow for quicker

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<sup>34</sup> Ibid.

<sup>35</sup> Ibid.

identification and resolution of technical deficiencies. The net-centric make-up of the Lean model will begin to build indicators and historical data that will allow engineering analysts to identify potential problems and shortfalls before they become critical and possibly disrupt the sustainment process or mission readiness.

The drawback to this model is that in consolidation of functions, it places a greater demand for diversity and technical knowledge. Additional training and possibly growth in the number of jobs may be required. Instead of managing one specific area, an individual will need to learn how one's item interacts throughout the process and be able to track it from start to finish. Additionally, it will be incumbent upon the In-Service Engineers to maintain accurate metrics that will give a true indication of the performance of the system in order to maintain a truly Lean operation.

#### Does Lean Work

Lean works in the civilian industries. Can it work in the Department of Defense? Evidence suggests that it can.

In 1998, the U.S Navy and the U.S. Air Force joined together their efforts to manage the Cartridge Actuated Device/Propellant Actuated Device (CAD/PAD) program. The two services realized the benefit to be had if they established a joint program to manage the CAD/PAD device.. The device is used in aircraft escape systems and other applications. The program managers in the Navy and Air Force put aside their biases and misplaced distrust to form a joint effort in the procurement and sustainment of the CAD/PAD devices. These are the key attributes of that program:

- Operation as a joint integrated product team/competency aligned organization with the Service affiliation of team members transparent to users.

- Assumption of responsibility by the U.S. Navy, as lead Service, for an important factor (the escape system) in the operational readiness of aircraft in all services
- Employment of jointness in the sustainment phase of the life cycle, rather than the more traditional development phase.
- Use of best practices and continuous improvement with strong emphasis on supporting the customer.
- Management of a commodity, rather than a weapon system.
- Creation as an initiative from the working level, rather than a directive from the top.<sup>36</sup>

The Joint Program team consists of all key players from the manufacturing of the part to the program manager to the maintenance personnel that put the part on the aircraft. The old labor and paper intensive method that was used to order a part before was replaced by a phone line direct to the supplier. The maintenance personnel can pick-up the phone and order directly from the stock point, much like civilian maintenance personnel are able to do. This order is then verified by the stock point operator using current information input by the maintenance personnel and shared via a collaborative work environment system. After verification, the part is then shipped overnight to the maintenance site that requested it. Cycle time for this process has been reduced from 210 days to 7 days.

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<sup>36</sup> Ibid.

By minimizing duplicative processes and optimizing their resources, it is estimated that this program saves \$825,000 per year. This includes savings from combined procurement contracts, reducing the number of contracts required and the ability to buy more for less. The idea is to reduce costs with bulk purchases rather than two smaller contracts at an increased price per item.

Likewise, the Army has adopted Lean into their depots. MG James Pillsbury, the Commanding General for the U.S. Army Aviation and Missile Command, has recognized the need for change in depot operations and practices. He has stated in a video from AMCOM's Office of Continuous Improvements, "We are an Army at war facing new challenges everyday... Innovation and change are vital to stay postured for any new challenge." A large part of this change is Lean practices. He goes on to say, "It is a long term commitment to improving performance that ensures that whatever we provide the warfighter is done most effectively and efficiently, with minimal waste and optimum value-added activities..."<sup>37</sup> His comments and enthusiasm for the Lean program are backed by GEN Benjamin Griffin, Commanding General, U.S. Army Materiel Command.<sup>38</sup>

These statements are important, not only because MG Pillsbury represents some of the largest depot in the U.S. Army (Corpus Christi Army Depot, Letterkenny Army Depot, and Red River Army Depot), and General Griffin is overall responsible for all depots in the Army system, but also because it is an indicator that change is occurring. MG Pillsbury goes on to discuss the importance of Life-Cycle Management Commands:

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<sup>37</sup> Office of Continuous Improvement Times, *MG Pillsbury: HOOAH for Lean Awareness*, Volume 1, Issue 1, April 2005 (<https://oci.redstone.army.mil>).

<sup>38</sup> Ibid.



Integration is the desired state and is attained by collocating supporting personnel with a single weapon system authority and establishing common metrics and process improvement tools, such as robust information flow from the field, readiness modeling capability, Lean, and Six Sigma. This integration is expected to produce significant improvements in the weapon system support to the warfighter and equally significant improvements in life-cycle management effectiveness and efficiency.<sup>39</sup>

### Corpus Christi Army Depot

Corpus Christi Army Depot (CCAD) is a U.S. Department of Defense Center of Industrial and Technical Excellence for Rotary Wing Aviation Maintenance. Today, CCAD provides helicopter repair and overhaul capability to all the U.S. military services, as well as numerous foreign military organizations. Thirty percent of the Depot's workload is obtained from other services and includes maintenance for the SH-60 Seahawk, AH-1W Super Cobra Attack Helicopter, MH-60 Pavehawk, and UH-1N Huey Helicopter. CCAD is a full-service facility with the ability to restore airframes, engines, and components to like-new condition including crash-damaged aircraft. Since it began, the Depot has overhauled or repaired more than 12,922 aircraft. The average annual total funded workload, based on 1997 history, is \$307 million.<sup>40</sup>

Given the scope and the workload at CCAD and the focus of the leadership with the implementation of Lean, it only makes sense to try and capitalize on the benefits Lean has to offer. In 2001 the Army's depots were told to begin the training and assessing process of Lean Six Sigma. Six Sigma at many organizations simply means a measure of quality that strives for near perfection. Six Sigma is a disciplined, data-driven approach

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<sup>39</sup> Pillsbury, James H. ,Major General, & Bogosian, Paul, *Life-Cycle Management Underway at Redstone Arsenal*, ARMY AL&T, November-December 2004, pg. 18.

and methodology for eliminating defects (driving towards six standard deviations between the mean and the nearest specification limit) in any process -- from manufacturing to transactional and from product to service.<sup>41</sup> After Corpus Christi Army Depot (CCAD) completed its initial assessment, it identified several areas that it could begin working the Lean principles into.

Corpus Christi Army Depot embarked on the Lean Six Sigma journey in 2001 with the signing of a partnership agreement with General Electric. GE introduced CCAD to Lean Six Sigma and the results have been outstanding. A data driven methodology combined with the Kaizen events was used to improve many aspects of the engine production. A Kaizen event is described as any action whose output is intended to be an improvement to an existing process.

Kaizen Events are commonly referred to as a tool that :

- 1) Gathers operators, managers, and owners of a process in one place
- 2) Maps the existing process (using a deployment flowchart, in most cases)
- 3) Improves on the existing process
- 4) Solicits buy-in from all parties related to the process

Kaizen Events are an extremely efficient to quickly improve a process with a low Sigma score. Kaizen Events are also useful for convincing organizations new to Six Sigma of the methodology's value. The true intent of a kaizen event is to hold small events attended by the owners and operators of a process to make improvements to that process which are within the scope of the process participants.<sup>42</sup>

The efforts of these Kaizen events have resulted in turn around time reductions of 65% in Power Turbine Modules, 63% in Cold Section Modules and 41% in engines. Production increased by 90% and inventory reduced by 9%. Variation in delivery times

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<sup>40</sup> Best Manufacturing Practices, Corpus Christi Army Depot, 4/14/2003, <http://www.bmpcoe.org/bestpractices/internal/ccad/summary.html>.

<sup>41</sup> [http://www.isixsigma.com/sixsigma/six\\_sigma.asp](http://www.isixsigma.com/sixsigma/six_sigma.asp), Six Sigma - What is Six Sigma?.

has been reduced by 83%. Following AMC guidance, CCAD formally introduced Lean to the Blackhawk Recap line in October 2003. Consolidation of production efforts has resulted in reduction of aircraft travel from 5.5 to 1 mile; space requirements have reduced by 276,000 sq.ft., buildings utilized have been reduced from 8 to 4. Lean Six Sigma is quickly becoming a way of life at CCAD. As can be evidenced in the before and after photos from CCAD, Lean has brought simplicity, organization and reduced required space, all of which directly contribute to the improved performance numbers.



**Figure 10 CCAD Before and After Lean**  
Letterkenny Army Depot

Letterkenny Army Depot (LEAD) also embraced the Lean concept and similarly realized some significant changes and improvements after they conducted their Lean activities. During CY03, LEAD came fully on-board and embraced the AMC Lean initiative. Eighty-three individual Lean events were conducted across the depot within the Directorate of Maintenance (DOM), Directorate of Public Works, Directorate of Supply and Transportation, Directorate of Contracting and the Depot HQs area. By year-end 40% of the depot's personnel were directly involved in Lean activities, which touched about 69% of the total DOM workload. First pass Lean improvements were

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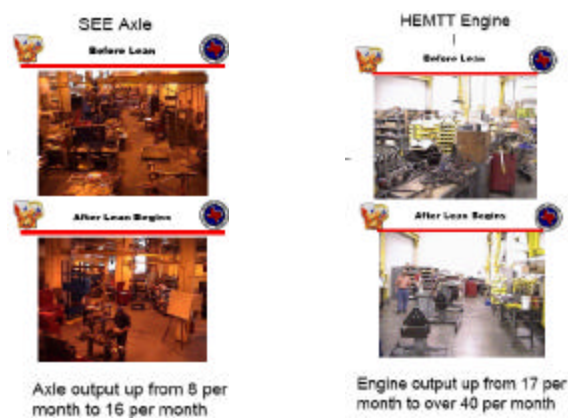
<sup>42</sup> [http://www.isixsigma.com/dictionary/Kaizen\\_Event-411.htm](http://www.isixsigma.com/dictionary/Kaizen_Event-411.htm), Kaizen Event.

completed for both PATRIOT Launcher and Antenna Mast Group and events were started in PATRIOT Radar and secondary programs resulting in \$4.5M in documented savings returned to AMCOM Lower Tier Project Office with projected savings of \$30.7M thru FY09. A first pass occurs after an area or production line is established using Lean tools in order to demonstrate the efficiencies gained through the implementation of the new concepts. The idea is to get other areas interested in improving their areas of production by incorporating similar improvements. Having the first pass through the PATRIOT launcher and Antenna Mast Group and seeing the success that Lean has afforded, other areas began the process to becoming Lean as well. Lean activities were continued for the Special Operations Command (SOCOM) Ground Mobility Vehicles (GMVs) and initiated for the new RDECONM workloads associated with Force Provider and the Biological Integrated Detections System (BIDS). LEAD was recognized by Commanding General, General Paul Kern as being an AMC leader for Lean.<sup>43</sup>

Other depots within the Army are succeeding in the implementation of Lean as well. Below are photos from the Red River Army Depot, showing similar before and after Lean improvements. The production and efficiency ratings are comparable to the other Army depots previously shown. The overarching theme is that the U.S. Army Materiel Command and its commander, General Benjamin Griffin, have embraced Lean as the way ahead.

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<sup>43</sup> Joint Service Best Business Practices, Army, Depot Logistics Business Systems Modernization, <http://www.jdmag.wpafb.af.mil/bestbusarmy.htm>.



**Figure 10 RRAD SEE line and HEMTT Line Before and After Lean**

To continue the success of this new initiative in the military, in June of 2005, a team from AMCOM's Office of Continuous Improvements surveyed several of the Army's rotary wing reset sites, including:

- Ft Campbell, KY, Aviation Logistics and Maintenance Division
- Hunter Army Air Field OLR and DOL at Ft Stewart, GA
- Williams-Gateway (Mesa, AZ)
- Ft Hood, TX OLR and DOL
- Ft Lewis, WA OLR
- Wheeler Army Airfield OLR

The team's purpose was to conduct an initial assessment and value stream analysis on the operations at each site. Its goal is to reduce the turn-around-time (TAT) of an aviation platform by 20%. In May of 2005, the average TAT was 90-150 calendar days. Primarily a Lean objective, these efforts were done to bring the whole depot level

maintenance procedure into synchronization. Recommendations for improvement involved more than just the AMCOM specific activities but also included changes for the Defense Logistics agency as well.

#### Warner Robbins Air Force Base

Clearly the Army is not the only service on the Lean track to success. Warner Robbins Air Force Base in Georgia also implemented Lean to increase productivity and reduce waste. Major General Dennis Haines, Air Logistics Commander at Warner Robbins Air Force Base during 2001 was quoted as saying in an interview with Manufacturing News and Technology:

Today, we're doing the same number of wings in the 37 days, but we're doing it in a five-day, two shift operation-16 hours a day. We've moved 25 people out of the production area to other areas where we needed them. We reduced our overtime expense by \$1.5 million; we saved another \$1.5 million by the people we moved out of the area; and surprisingly enough when we went to the cellular, one-piece flow, we went from individual tool kits and multiple pieces of special equipment, to equipment specialized for that particular portion of the flow and we saved \$1.2 million in tools.<sup>44</sup>

With a short statement, Major General Haines covered a large amount of significant information that is the result of a dedicated effort to change depot procedures within the U.S Air Force for the better. He demonstrates the most significant factor, at least in the eyes of the taxpayers, are the dollars that are saved through these new methods.

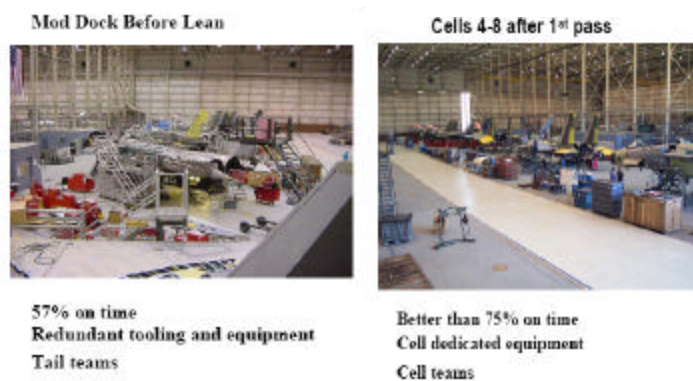
A look at the success of the F-15 Stabilizer shop also shows these impressive and telling successes:

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<sup>44</sup> Manufacturing News, Lean takes root at Warner Robbins Air Force Base, Interview with Major General Dennis Haines, November 16, 2001.

- Output from the shop increased 60% ( On average, an increase of 50 stabilizers per month to 80 stabilizers per month)
- Flow days decreased 80% (amount of time the product takes to move through the Stabilizer shop.)
- Work In Progress was reduced by 72% (direct result of the flow day decrease)
- The shop became one rapid improvement team
- No additional people needed<sup>45</sup>

These photos illustrate the organization and simplicity gained through the change.



**Figure 11 Warner Robbins Before and After Lean**

As early as 1998, all the Services had begun to use Lean in their depots. Like any other major paradigm shift, this will take time. And while the services can be lauded for their efforts to improve from within, a full realization of the benefits of Lean will only be achieved once the Services begin to look to each other and integrate their processes.

<sup>45</sup> Whitmore, Tim, Manager Consulting Services (Army), Goschke, President, Simpler Consulting, Long, Brian, Anteon, Lean Depot Repair, [www.simpler.com](http://www.simpler.com).

Some big steps have been taken as has been illustrated but these are only a portion of the whole system. With reducing DoD budgets, the military is being forced to rethink how to manage the life cycle of the military systems. Many services have taken a positive step in the right direction as has been illustrated above. So why is everybody not on board? Change is hard and Lean is not perfect for everyone.

### **LEAN: A BIG CHANGE**

All this change appears to be for the good but it is expensive, time consuming and risky. Plus, how can you expect the military to perform like Toyota? Toyota is a



corporation that is run by a much less diverse and complicated bureaucracy than that of the Department of Defense and replication of process improvements would seem impossible. If the CEO wants to institute a change of direction for their product line, then he does it with a follow-on vote by his board, who by the way, are most likely to vote in favor of any new proposal if the CEO chairs it and is fiscally beneficial. Is this just speculation? Maybe, but just imagine all the Services gathering and agreeing on one of the Services being responsible for all aspects of a weapon system. Would this even be possible? Probably not, and for several reasons.

One of the biggest reasons is because it would mean trusting another Service to give the care, attention to detail and dedication to your piece of equipment, equivalent to the attention the equipment would receive in its parent Service. What is to say that, should the one joint maintainer concept be emplaced, the Service responsible for the action wouldn't place the needs of its Service in front of the needs of the other Services?

Next and noticeably most important is the issue of dollars. It has been discussed in this paper that money plays a key role in the processes that the DoD chooses to accept and not accept and that those funds available continue to decrease. Tied to that, how willing are the Services to dedicate funds to another Service to perform maintenance that they may feel they could perform more efficiently and to a higher standard of quality? Additionally, this takes the Services "flexibility" away from within itself by dedicating funds outside of itself.

Even the proponents of the Lean Six Sigma concept agree that it doesn't always work. In fact there have been instances where it hasn't worked. Whirlpool tried to follow the lead of General Electric with the institution of Lean Six Sigma practices; it

didn't realize anything but a 12% decrease in stock value over a two year period that directly followed the new program's institution. Important to note is that the implementation of Lean is not an instantaneous success. The failure was attributed to the lack of commitment by the Whirlpool Corporation to the Lean process. After evaluation of the two year results and consideration of the factors that caused the lack of success, Whirlpool rededicated itself to Lean but this time in whole. Since the initial trial and failure, Whirlpool has realized success both in its North American and European markets. Its 2004 annual report discussed how working from a global platform, Whirlpool was able to use key operational initiatives for maximum impact. Creating breakthrough solutions for the most difficult challenges, Whirlpool's Lean Six Sigma initiative known as Operational Excellence, has resulted in more than \$175 million in global manufacturing savings.<sup>46</sup>

For Lean Six Sigma to work, leadership must embrace the concept and commit to it. This means training at all levels so that the employees can become familiar with the new concepts. Time and money will need to be made available to provide this new training. This could affect the throughput of depots at a time when they are already under the strain of an increased OPTEMPO and aging equipment.

Consider what is necessary for an organization to begin the Lean process. Lean is not a "quick fix", it requires resources, both time and money, and an acceptance of an element of risk. Even the most devoted Lean teachers agree that this new philosophy can

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<sup>46</sup> Marx, Michael, *Whirlpool-Operational Excellence*, 21 June 2005, <http://blogs.isixsigma.com/index.asp?ci=14&s=category>.

be disruptive, at times chaotic, that it can hurt company morale, and that it won't deliver quick, measurable returns.<sup>47</sup>

Some examples of paradigm shifts that face the Department of Defense have been seen in civilian sector industry as well. There are at least two paradigms at work:

"Inventory Protects," and "Large Batches Reduce Changeover Time."

#### Inventory Protects

Inventory is like insurance. We keep it to protect us against things that can go wrong:

- Machines break down.
- A percentage of the production has defects.
- Suppliers are unreliable.
- Bottleneck machines run out of stock.
- The forecast is unreliable.

Inventory is kept so that even if these things go wrong, production can keep going.

Inventory allows one to hide the problems that arise in the system. As long as there is material on the shelf, regardless of what happens to the production line, the customer's needs can always be met. With this paradigm, if a small batch is implemented, changing the production line to produce a small order, the pull system is used. The pull system is in effect when the customer's order dictates what the production line makes rather than industry meeting the customer's need through inventory. Change-over of a production line costs an organization money and time. So it is easy and understandable why at this

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<sup>47</sup> Phillips, Todd, Lean Manufacturing, Building the Lean Machine, Advanced Manufacturing, <http://www.advancedmanufacturing.com/Leanmanufacturing/part1.htm>.

point, the temptation to go back to the old way is hard to resist.

### Large Batches

Large batches reduce changeover time. The old paradigm says run large batches so that fewer changeovers are needed. If it takes two hours to change from one product to another and one hour to run the customer's order, eight orders may be combined to achieve a run time of 80%.

If small batches are run, say one order at a time, run time would be only 33%. Operators would complain about the extra changeover work and managers would worry about downtime - and once again, the temptation to go back to the old way would be hard to resist.<sup>48</sup> What's the answer? It seems that despite the method that there will be some kind of drawback. Lean teaches an organization to remain flexible and that small batches can be productive if the organization properly maps its process to reflect change. Change is a constant in the Lean model.

Here is the penny exercise to show the benefit of changing from a large batch process to a waterfall small batch process or parallel small batch process.

The exercise simulates processing work in the form of flipping pennies from heads to tails and back. Four people in the Team sit at a table or other hard surface in a line beside each other. The surface must allow for easily sliding the pennies. The fifth person, the Manager, starts the process and times it. The Team will process the pennies twice...

#### **First Pass - Waterfall Large Batch**

1. The Manager gives all the pennies to the first person in the Team and notes the start time. The pennies should be in a big jumble.
2. The first Team member chooses a side (heads or tails) and flips all

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<sup>48</sup> Lean Manufacturing, Will it Die Like the Other Buzzwords?, Cataly\$t, Management Issues, Grant Thornton, [http://www.granthornton.ca/mgt\\_papers/MIP\\_Lean-Manufacturing.pdf](http://www.granthornton.ca/mgt_papers/MIP_Lean-Manufacturing.pdf).

the pennies onto that side.

3. The person with the pennies passes the whole pile of pennies to the next person. That person then flips all the pennies to the other side.
4. Repeat step three until the last person on the Team has flipped them.
5. The manager notes how long this took.

### **Second Pass - Waterfall Small Batch**

1. The Manager gives all the pennies to the first person in the Team and notes the start time. The pennies should be in a big jumble.
2. The first Team member chooses a side (heads or tails) and flips all the pennies onto that side. As each penny is flipped, the Team member passes it along to the next person.
3. Each person flips their pennies as quickly as possible and immediately passes them on to next person.
4. Do this until they are all flipped.
5. The manager notes how long it took for the first penny to go through all four Team members, and how long it took for all of them to finish.

### **Optional Third Pass - Parallel Small Batch**

1. All the pennies are in a random jumble in the middle of the table.
2. One Team member calls heads or tails and the manager notes the start time.
3. Each person grabs a penny at a time from the pile.
4. All working at the same time as quickly as possible, each person flips the pennies first so they are all the same as the original call if needed, and then three more times
5. As each penny is finished 3 or 4 flips (as appropriate) it is pushed into a separate done pile in the middle of the table.
6. The Manager records the time for the first penny to be put into the done pile and for all of them to be completed.<sup>49</sup>

The time to complete the process of flipping pennies decreases with each small batch process. But giving up an old way of doing business is a risky move not only on the production capacity side of the house in order to retrain your personnel but also in a comfort level sense. Instead of one individual being skilled at one task, flipping the penny once from heads to tails or vice versa, that individual will have to be trained to do more than one task, flipping the penny multiple times like in the Parallel Small Batch process. What does this mean? A worker will be responsible for the product from its

introduction through the end, capable of completing more than just one task. This will mean a big change and most likely an even bigger effort to retrain your workforce to accomplish the multiple tasks. Even if the retraining of the workforce could be accomplished without sacrificing throughput capacity, the entire workforce needs to believe and institute the new changes. Without total buy into the Lean concept, the endeavor could result in disaster. There needs to be a clear path of march for all to follow.

In Dr. Johnson's book, *Who Moved My Cheese*, there were seven truths that he calls the handwriting on the wall:

- Cheese Happens
  - They keep moving the cheese
- Anticipate Change
  - Get ready for the cheese to move
- Monitor Change
  - Smell the cheese often so you know when it is getting old
- Adapt to Change Quickly
  - The quicker you let go of old cheese, the sooner you can enjoy new cheese
- Change
  - Move with the cheese
- Enjoy Change
  - Savor the adventure and the taste of new cheese
- Be ready to quickly change again and again

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<sup>49</sup> Bertieg, Mishkin, Penny Queing Exercise-Lean Process, Agile Advice, December 19, 2005

- They keep moving the cheese.<sup>50</sup>

These truths are many of the same principles of the Lean concept. They seem to be common sense but regardless of how easy they are to read or say, they are hard to do. Cheese is the reward of successful operations and for the military depots to continue to enjoy the success; they must change or become extinct.

### **WHAT ARE THE OPTIONS**

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[http://www.agileadvice.com/archives/2005/12/penny\\_queueing.html](http://www.agileadvice.com/archives/2005/12/penny_queueing.html).

<sup>50</sup> Johnson, Spencer Dr., *Who Moved My Cheese?* G.P. Putnam's Sons, New York, 2002.

There are a full spectrum of options with regards to current depot maintenance operations and the future of the depots. The intent or goal of looking at the restructuring of depot procedures is to ensure the production of a quality product and the delivery of that product to the unit in time for training and deployment. Also included in this goal is the profitability or attained maximum efficiency of the depot system. Here are three possible options with a possibility of variation or integration between the three.

One option may be for the depots to be Government Owned and Contractor Operated or GOCO. In this instance, the depots would provide the work for core maintenance procedures with the rest of the work meted out following a competitive bid to private industry to perform the remainder of the service at other depots. Maintaining a core competency in depot operations is important however, many may contend that during times of peace, the work force within the depots is being under utilized and therefore not being efficient. By adopting a GOCO concept, the underutilized workforces and physical plant could be used for other endeavors in the private sector. Partnering with industry could possibly form strategic partnerships with companies that otherwise would be competitors of the GOCO depots. Through these partnerships, some of the older core missions could possibly push to peripheral activities that could be outsourced or even removed from the operation as they become obsolete. As new required capabilities arise, they can be acquired through the private sector and incorporated into the GOCOs. This can be done because the GOCOs work much like a corporation and can look for the best long-term value rather than being driven to lowest cost.<sup>51</sup> This would be a favorable option for the Congressman who has a large portion of his



constituents working in depots. The private sector, on the other hand, is not fond of this option due to the cost of overhead that they incur in bidding for a contract. The private sector must include taxes, retirement, medical benefits, and profit in their bids where the government does not.<sup>52</sup>

A second option would be to continue on the path that we are on right now with each Service implementing changes and improvements within their depots to increase productivity and profitability. Competition would be used as a driver for the depot's continued existence and retention of workload. The competition will continue to drive each Service to look for innovative ways such as Lean to improve its productivity and could possibly result in increased cost savings for the DoD in a resource constrained environment.

The third option for consideration is the integration of the depots into a joint capability for core components. This would require a change in legislation and a restructuring of dollars and their allocation within the Services. To fully ensure a jointness flavor, depot commanders and deputies could be from services other than the host depot. The Joint Depot Maintenance Program already exists, outlining and incorporating many of the Services current procedures but requiring more directive guidance in order to become effective.

This option would allow services to concentrate on the core competencies and rely on the Joint Depot Management Program to conduct reset and recapitalization of all

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<sup>51</sup> Held, Bruce, Horn, Kenneth, Hanks, Christopher, Hynes, Michael V., Steinberg, Pernin, Paul Christopher, Medby, Jamison Jo, Brown, Jeff, *Seeking Nontraditional Approaches to Collaborating and Partnering with Industry*, Rand, 2002, pg. 64.

<sup>52</sup> Dornheim, Michael A., *Aviation Week & Space Technology*, Jan 18, 1993, p. 51.

Service's equipment.

### **RECOMMENDATION**

The three options presented represent a varied outlook at what the possibilities for the future of depot operations can be. Given the success that each service is having with

its move to the Lean manufacturing concept and with the transformation process within the military, a combination of the second and third options seems most practical.

Option one presents a seemingly palatable option, that of removing the military almost holistically from the depot process. It does bring to consideration what kind of control the military would retain over the cost of the process, the availability of its assets within the depot system and the productivity to demand issue based upon established current contracts with industry. However, by allowing the depots to be operated by organizations other than the military, this will free up service members and the Services to focus on core competencies. The depots would then have the ability to adapt and change as quickly as they do in the civilian sector, by passing much of the DoD bureaucracy. While there is risk of not having ownership of the process, the benefits are considerable and must be taken into account.

While the first option presents some enticing benefits it carries with it some equally as disconcerting drawbacks. Understanding that the GOCO concept can lead to innovations and efficiencies, it also requires the ability to predict the nature of future conflicts. A predicated factor to the success of the GOCO concept is that older core activities could be moved to outsourced partners and newer ones can be adopted by the depot. Unfortunately, given the current trend of a reducing DoD budget and the fact that many Services are having to cut future programs in order to curb spending, this idea of phasing older core competencies out of the depots to make room for newer ones may not be as easily realized as anticipated. Services are being asked to reset and recapitalize their current weapon systems rather than replace them with newer models that would support the GOCO model benefits. Additional to that is the matter of who possesses

ownership of the depot process. Without a share in the decision making and relying on a profit dictated process, the military could lose the critical capability to surge production to meet demand without having to spend extra funds. If many of the peripheral activities are pushed to partnered industry then the depot will have to pay for any amendment or addition to current contracts in order to meet its surge requirement. There still needs to be a chain of accountability that the Services can influence and unless the GOCO model can produce that chain of accountability, option one will remain a difficult one to initiate.

Combining the benefits of option two and three, DoD can best serve itself, the military service members and the taxpaying American people. The Services should continue to improve their depots with the use of Lean Six Sigma practices to maximize efficiencies and productivity from within. As the depots continue to demonstrate that they are successful, management of the depot systems under a joint program should begin incorporating leaders from all the Services and removing the burden of depot operations from a single branch while placing the function under the Joint Depot Maintenance Program. The program already provides guidance on joint depot procedures but a joint management system needs to be in place to capitalize on the individual depots and their increased efficiencies and productivity through Lean Six Sigma. By removing the burden of depot operations from the Services and placing it under a joint maintenance program it will allow the Services to focus on their core competencies of training and fielding a force to meet the National Security Strategy and National Defense Strategy objectives.

### **CONCLUSION**

As discussed earlier in this paper, the increased OPTEMPO of the services coupled with the reduction in budgetary funding place the depots in a very critical

position as new weapon system purchases are being delayed and legacy weapon systems are being reset and recapitalized. There needs to be a new way of doing business and thinking about how the military is going to continue to field a force ready and capable of meeting its requirements. Having laid out the key components for consideration on the way ahead with the Joint Depot Maintenance Program, reset and recapitalization of legacy equipment, the Depot system, the Defense Industrial Base, an examination of current and proposed sustainment systems, and a demonstration of the successes of the newly adopted Lean manufacturing concept, it is apparent that regardless of the hesitancy to change, the Services have started on a path that may well lead to a Joint effort in the future.

The framework for this to happen is already in place with the JDMP. The manning, sourcing and governance of the JDMP will be a matter for the Services and OSD to iron out. As the military's financial resources continue to be constrained and reliance on older systems lasting longer becomes the norm, a consolidation of like minded leaders who agree on the already growing efficiencies within the depots is a step that the OSD and services need to move towards. Depots should remain in place, thus not disturbing the concerns of workers and Congressmen, but like weapon systems and the procedures that prove to be most effective should be placed under the one manager. Doing so will maintain the redundancy needed in a surge required situation as well as standardize and reap the benefits of the most effective tools within that manager's systems.

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